

## HISTORY AND MORPHOLOGY OF FAULTING IN THE NOCTIS LABYRINTHUS-CLARITAS FOSSAE REGION OF MARS

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The topographically high areas cut by Noctis Labyrinthus, Noctis Fossae, and Claritas Fossae [1] were subjected to only minor resurfacing during and following local tectonic activity. Principal resurfacing materials consist of lava flows from Syria Planum and Tharsis Montes [2]. Thus, these areas preserve much of the fault record produced by tectonism in this region. Although recent geologic maps of the area have been produced from Viking images [2,3], the only detailed fault histories available until now were described from Mariner 9 images [4,5]. Much of the faulting in the Tharsis tectonic province was centered in Syria Planum [6,7]; therefore, understanding the fault history in this region is critical to understanding the stress history and tectonism of Tharsis as a whole.

Our preliminary mapping of fault patterns in the Noctis Labyrinthus-Claritas Fossae region of Mars reveals several distinct stages and morphologies of faulting. The regional fault history (from oldest to youngest) is as follows:

(1) Broad, mostly east-trending grabens cut into older fractured terrain and basement material [2] of southern Claritas Fossae. The graben-bounding scarps became degraded and were embayed by smooth deposits.

(2) Long, narrow grabens oriented radial to Syria Planum form dense, parallel-to-fanning areas of faults in Noctis Fossae and throughout Claritas Fossae (Fig. 1). Although much of the faulting preceded resurfacing from Syria Planum, some later faults cut low, smooth areas of the Noctis area and flows of the lower member of the Syria Planum Formation [2] south of Syria Planum (south-central part of area in Fig. 1). A few east-trending faults are radial to and lie west of Syria Planum.

(3) Concentric fractures formed mainly north and west of Syria Planum (Fig. 2) and appear more pristine, wider, and deeper than local radial fractures of the previous stage. They are dense at the north and west edges of Syria Planum, and some cut the upper member of the Syria Planum Formation in southwestern Syria Planum.

(4) Collapse pits, pit-crater chains, rilles, and deep grabens characterize the deformation that collectively describes Noctis Labyrinthus (Fig. 3). The orientations of these features are controlled mainly by the preexisting radial and concentric fault systems; additionally, some tangential, WNW- to NNW-trending faults and collapse features were produced. This activity was most significant north and east of Syria Planum, particularly at the west end of Valles Marineris. Sinuous rilles that may have been sites of lava extrusion formed on Syria Planum.

(5) Arcuate, scallop-shaped and linear NNW-trending faults developed along the east side of the Claritas rise and in southern and western Syria Planum, cutting circumferential faults of Syria Planum and the upper member of the Syria Planum Formation; northwest-trending faults in the Noctis area cut across the collapse depressions of the previous stage (Fig. 4).

Although this fault history generally agrees with that of [4,5] on a local basis, their regional syntheses of the fault patterns and their tectonic inferences differ from those presented here. The fault history ascertained above forms the basis upon which we set forth the following style and timing of the tectonic history of the region, given stress-field predictions based on geophysical models [8-10] and the stratigraphic positions of the faults and the materials they cut or underlie [11]:

Early to Middle Noachian Epochs: North-south extension produced east-trending grabens in southern Claritas Fossae; faults scarps were eroded and embayed.

Late Noachian to Late Hesperian Epochs (stage 1): Isostatic uplift centered in Syria Planum produced radial fractures (Fig. 1).

Late Hesperian Epoch (stage 2): Flexural loading of northern Syria Planum caused subsidence and concentric fracturing (Fig. 2).

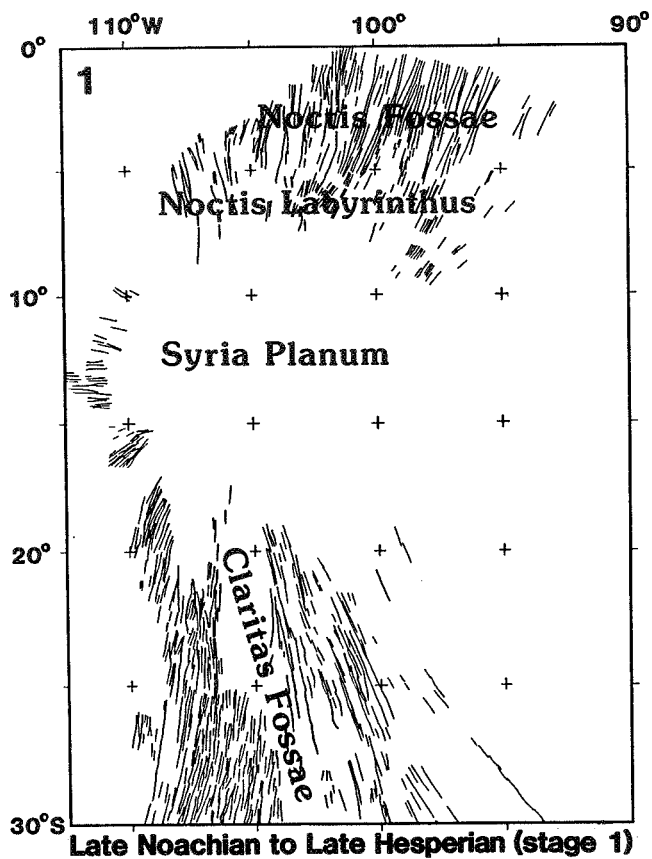
Late Hesperian Epoch (stage 3): Uplift of the Noctis area north and east of Syria Planum initiated collapse that may have been intensified by subsurface withdrawal of magma and volatiles (Fig. 3).

Early Amazonian Epoch: Lowering of the eastern flank of the Claritas rise produced NNW-trending grabens and normal faults (perhaps related to uplift of the Claritas rise [12]); northwest-trending faults in the Noctis area may be related to this tectonism.

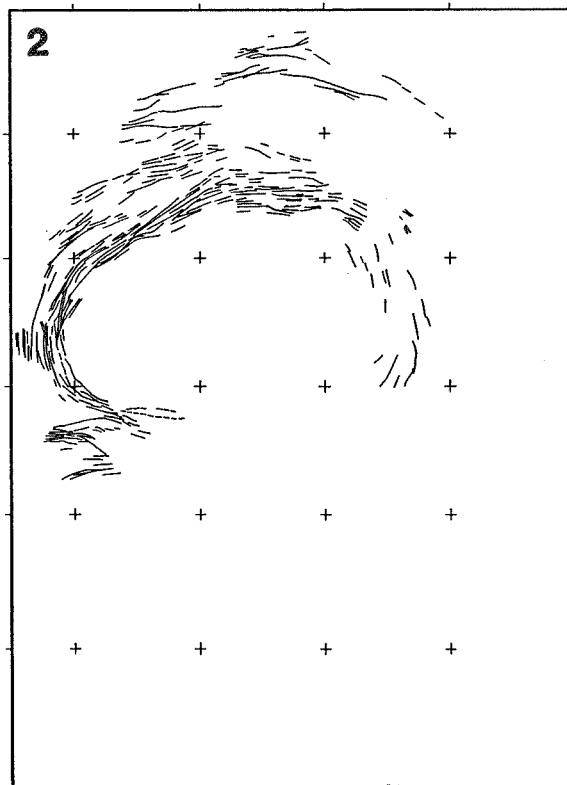
The structures corresponding to these tectonic episodes appear to have, in most cases, distinctive overall morphologies. They differ in shape (e.g., grabens vs. pit-crater chains), spacing (between faults and between graben-bounding faults), vertical throw, fault-scarp slope angle, continuity (lengthy vs. segmented), and so forth. With the aid of photoclinometry to measure the vertical dimension, we intend to quantify such parameters so that the relation of fault style and morphology to tectonic and resurfacing history can be further analyzed.

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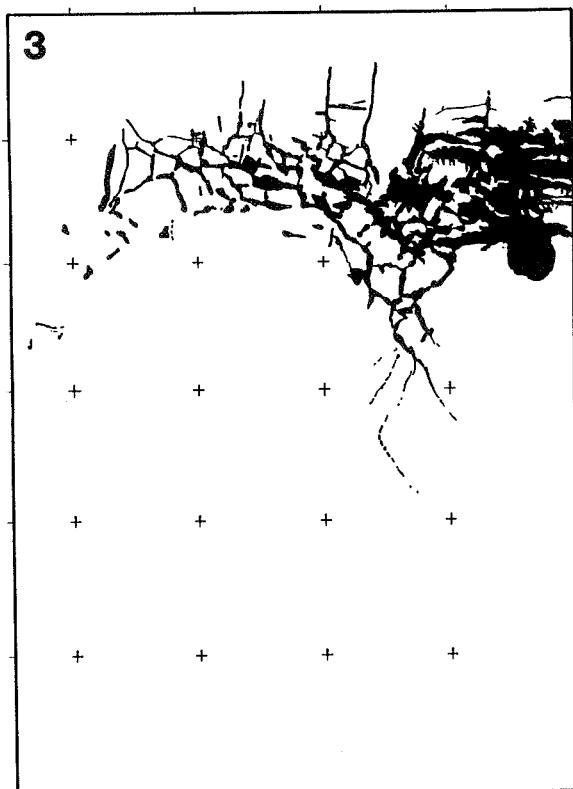
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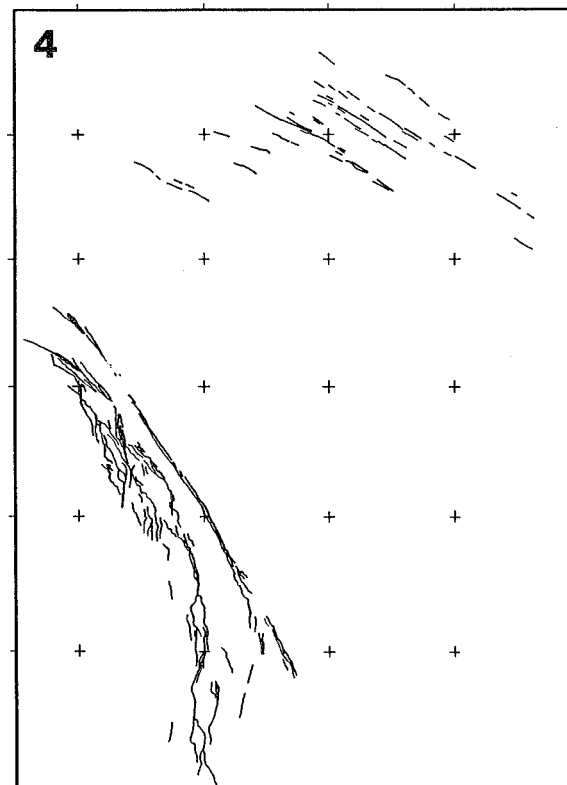
**Late Noachian to Late Hesperian (stage 1)**



**Late Hesperian (stage 2)**



**Late Hesperian (stage 3)**



**Early Amazonian**

**Figs. 1-4. Progressive structural development of the Noctis Labyrinthus-Claritas Fossae region of Mars.**